

**DRAFT  
GROUNDWATER INFORMATION SHEET**

**Chromium VI**

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*The purpose of this groundwater information sheet is to provide general information regarding a specific constituent of concern (COC). The following information is pulled from a variety of sources and data relates mainly to drinking water. For additional information, the reader is encouraged to consult the references cited at the end of the information sheet.*

<b>GENERAL INFORMATION</b>	
<b>Constituent of Concern</b>	Chromium VI (Cr <sup>6</sup> )
<b>Aliases</b>	Hexavalent Chromium
<b>Chemical Formula</b>	Cr <sup>6</sup>
<b>CAS No.</b>	18540-29-9
<b>Storet No.</b>	01032
<b>Summary</b>	The California Department of Health Services (DHS) adopted a regulation in 2001 that included Cr <sup>6</sup> as an unregulated chemical (no Maximum Contaminant Level, MCL) requiring monitoring. While “unregulated” usually refers to a contaminant that lacks an MCL, Cr <sup>6</sup> is regulated under the 50 µg/L MCL for total chromium. DHS will be adopting an MCL for Cr <sup>6</sup> by January 1, 2004. Based on DHS data through 2002, 1730 of approximately 2900 public drinking water wells (active and standby status) tested have had concentrations of Cr <sup>6</sup> ≥ 1 µg/L, with most detections occurring in Los Angeles, San Bernardino and Riverside Counties.

<b>REGULATORY AND WATER QUALITY LEVELS<sup>1</sup></b>		
<b>Type</b>	<b>Agency</b>	<b>Concentration</b>
Federal MCL (Cr <sup>6</sup> )	US EPA, Region 9	N/A
State MCL (Cr <sup>6</sup> )	DHS	Expected in 2004
Detection Limit for Purposes of Reporting (DLR) (Cr <sup>6</sup> )	DHS	1 µg/L
Others:		
Preliminary Remediation Goal (PRG) (Cr <sup>6</sup> )	US EPA, Region 9	100 µg/L
IRIS (non-cancer health effect, Cr <sup>6</sup> )	US EPA, Region 9	21 µg/L
Federal MCL (Total Chromium)	US EPA, Region 9	100 µg/L
State MCL (Total Chromium)	DHS	50 µg/L
DLR (Total Chromium)	DHS	10 µg/L

<sup>1</sup>These levels generally relate to drinking water, other water quality levels may exist. For further information, see A Compilation of Water Quality Goals (Marshack, 2000).

<b>SUMMARY OF DETECTIONS IN PUBLIC DRINKING WATER WELLS<sup>2</sup></b>	
<b>Detection Type</b>	<b>Number of Groundwater Sources</b>
Number of active and standby public drinking water wells <sup>3</sup> with Cr <sup>6</sup> concentration $\geq 1$ µg/L.	1730 of 2965 tested
Top 3 counties having public drinking water wells with Cr <sup>6</sup> concentration $\geq 1$ µg/L.	Los Angeles, San Bernardino, and Riverside
Number of active and standby public drinking water wells <sup>3</sup> with Total Chromium concentration $\geq 50$ µg/L.	49 of approximately 16,000.
Top 3 Regions having public drinking water wells with Total Chromium concentration $\geq 50$ µg/L.	Central Valley, Central Coast, and Los Angeles

<sup>2</sup>Based on DHS data collected from 1984-2000 (Geotracker). See Figures 1 and 2.

<sup>3</sup>In general, drinking water from active and standby wells is treated or blended so consumers are not exposed to water exceeding MCLs. Individual wells and wells for small water systems not regulated by DHS are not included in these figures.

<b>ANALYTICAL INFORMATION</b>		
<b>Method</b>	<b>Detection Limit</b>	<b>Note</b>
GFAAS and ICP-MS (screening methods)	1 µg/L	DHS approved for public drinking water systems
US EPA 218.6 or 7199	0.2 µg/L	
US EPA 7196 (colorimetric)	100 to 300,000 µg/L	May interfere with other compounds

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<b>Known Limitations to Analytical Methods</b>	Filtration of the sample immediately after collection is not recommended, adjust sample pH to 9.0 - 9.5, sample must be cooled to 4° C and analyzed within 24 hours. In some cases, it may be difficult to adjust pH to 9.0-9.5 for some waters (e.g., Colorado River). Filtration of sample immediately prior to the ion chromatographic determination is recommended. Colorimetric method is unreliable if high levels of permanganate are present in the sample.
<b>Public Drinking Water Testing Requirements</b>	In January 2001, DHS adopted a regulation identifying Cr <sup>6</sup> as an unregulated chemical requiring monitoring. As a result of the regulation, public water systems began collecting information on the presence of Cr <sup>6</sup> in their drinking water supplies. These data are needed to enable DHS to ascertain the extent to which Cr <sup>6</sup> is present in drinking water supplies, and to determine treatment costs associated with a Cr <sup>6</sup> -specific MCL. According to the new DHS regulation, all water systems in California will be tested for Cr <sup>6</sup> over the next two years. As of May 2002, Cr <sup>6</sup> sampling data from 2,965 drinking water sources have been reported to DHS.

<b>CHROMIUM VI OCCURRENCE</b>	
<b>Anthropogenic Sources</b>	Chromium is a metallic chemical that originates as a contaminant in the environment from the discharges of dye and paint pigments, wood preservatives, chrome plating liquid wastes, and leaching from hazardous waste sites. The greatest use of chromium is in metal alloys such as stainless steel; protective coatings on metal; magnetic tapes; and pigments for paints, cement, paper, rubber, composition floor covering, etc. The two largest sources of chromium emission in the atmosphere are from the chemical manufacturing and combustion of natural gas, oil and coal.
<b>Natural Sources</b>	Chromium is a metal found in natural deposits of ores containing other elements, mostly as chrome iron ore. It is also widely present in soils and plants. Most natural chromium in the environment occurs as Cr <sup>3</sup> . Under highly oxidizing conditions, pH >7, and with presence of minerals containing chromium, part of it may occur as Cr <sup>6</sup> dissolved in groundwater.  Naturally occurring Cr <sup>6</sup> may be associated with serpentized peridotite (serpentinite) of the Franciscan formation, e.g. Presidio of San Francisco. It is expected to occur in chromium containing formations such as peridotite or serpentinite under

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	oxidizing conditions. Chromate is found in the northern California (Klamath Mountains), and serpentinites are very common within the Coast Ranges.
<b>History of Occurrence</b>	<p>Cr<sup>6</sup> has been found in groundwater at several industrial sites where wood treatment or metal plating solutions have leaked or spilled. Cr<sup>6</sup> occurrence in groundwater became well known after Pacific Gas &amp; Electric (PG&amp;E) was accused of contaminating groundwater in the town of Hinkley (west of Barstow, CA). Cr<sup>6</sup> was used at the PG&amp;E facility to reduce corrosion at a natural gas compressing station. Contaminated groundwater was suspected of causing cancer and tumors in Hinkley residents. Since then, Cr<sup>6</sup> has been found at elevated concentrations in groundwater at several locations in California (City of Glendale in San Fernando Valley, Topock and Kettleman City). At some locations, such as the Presidio of San Francisco, Lawrence Livermore National Laboratory, Paradise Valley in Arizona and Atacama Desert in Chile, Cr<sup>6</sup> occurs naturally in groundwater. The recent sampling of drinking water throughout California suggests that it may occur naturally in many locations.</p> <p>As of May 2002, Cr<sup>6</sup> sampling data from 2,965 drinking water sources have been reported to DHS. Cr<sup>6</sup> was reported at concentrations of 1 µg/L or greater in 58% of the sources sampled. Cr<sup>6</sup> levels below 1 µg/L were reported for additional 27 sources. Concentrations up to 54 µg/L were found in drinking water sources in Los Angeles County. High concentrations of Cr<sup>6</sup> were also found in Merced County (33 µg/L), San Bernardino County (32 µg/L), Santa Barbara County (45 µg/L) Santa Cruz County (38 µg/L) and Yolo County (42 µg/L).</p>
<b>Contaminant Transport Characteristics</b>	Cr <sup>6</sup> is readily soluble in water and can migrate in the direction of the groundwater gradient. Under high Eh (oxidizing) and alkaline (pH above 7) conditions, Cr <sup>6</sup> may predominate in groundwater. However, in presence of organic matter, ferrous iron (Fe II) and sulfide, Cr <sup>6</sup> can be readily reduced to Cr <sup>3</sup> and immobilized. Adsorption of Cr <sup>6</sup> by clays, soils, and natural aquifer materials is low to moderate under near-neutral pH ranges, commonly encountered in groundwater.

## REMEDATION & TREATMENT TECHNOLOGIES

### In -situ Treatment:

Reducing  $\text{Cr}^6$  to the more immobile form  $\text{Cr}^3$  is effective in soil and groundwater. In several laboratory and field pilot tests, and full-scale remediation systems,  $\text{Cr}^6$  was removed using a permeable reactive barrier filled with zero-valent (Fe) iron granules, surfactant-modified zeolite or by injection of sodium dithionite. Also, the use of tin is being proposed to reduce  $\text{Cr}^6$  to  $\text{Cr}^3$  in the San Gabriel basin, as part of a process for the production of potable water.

### Above-Ground Treatment

Drinking water can be treated by different on-line treatment systems.  $\text{Cr}^3$  and  $\text{Cr}^6$  can be removed by activated carbon filter, reverse osmosis or ion exchange resin. The ion exchange method should be used with caution, as presence of other metals may interact with the process and decrease system effectiveness. Removal of  $\text{Cr}^6$  by seaweed biosorbent and *Bacillus* sp. within packed bed reactors has also been reported.

### Natural Attenuation

$\text{Cr}^6$  can be attenuated naturally under certain aquifer and soil conditions. Natural attenuation of  $\text{Cr}^6$  may occur in the subsurface environment through reduction by organic matter, iron hydroxides or sulfides, and pH from slightly acidic to alkaline. Prior to selection of natural attenuation as an option for remediation, the following conditions need to be demonstrated: 1) there are natural reductants present within the aquifer, 2) the amount of  $\text{Cr}^6$  and other reactive constituents do not exceed the capacity of the aquifer to reduce them, 3) the rate of  $\text{Cr}^6$  reduction is greater than the rate of transport of the aqueous  $\text{Cr}^6$  from the site, 4) the  $\text{Cr}^6$  remains immobile, and 5) there is no net oxidation of  $\text{Cr}^3$  to  $\text{Cr}^6$ .

## HEALTH EFFECT INFORMATION

$\text{Cr}^6$  is known to cause cancer in humans when inhaled. The hazards of airborne  $\text{Cr}^6$  in the workplace environment have been extensively documented. A number of scientific studies have found elevated rates of lung cancer in workers with occupational exposure to  $\text{Cr}^6$  by inhalation. A few studies of workers exposed to  $\text{Cr}^6$  by inhalation have shown an increase in cancers of the gastrointestinal tract and elsewhere. There continues to be uncertainty in the scientific community regarding whether or not  $\text{Cr}^6$  can cause cancer when ingested at levels found in drinking water.

## KEY REFERENCES

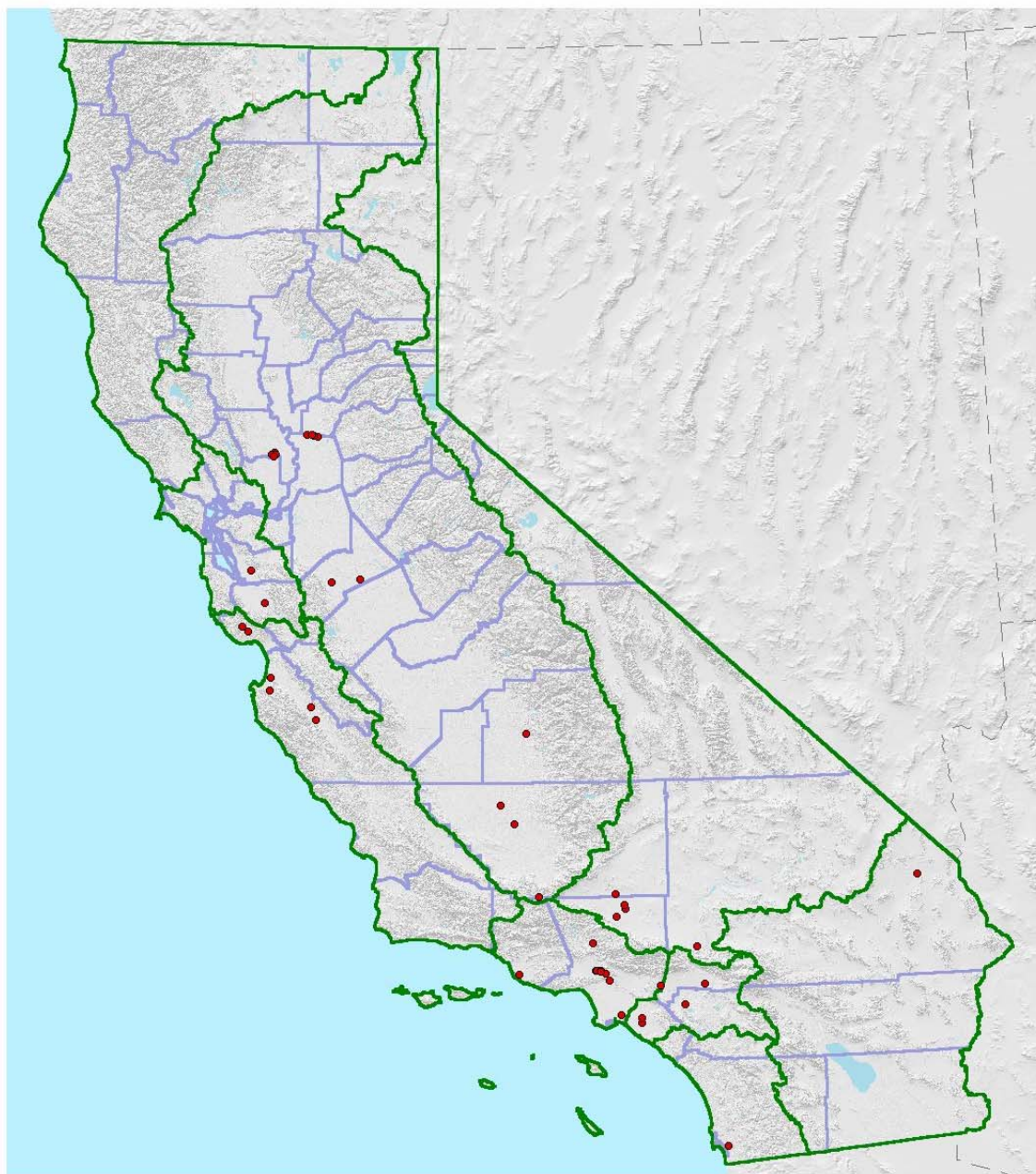
1. California Department of Health Services. *Chromium 6 (Hexavalent Chromium) in Drinking Water: Sampling and Analysis*.  
<http://www.dhs.ca.gov/ps/ddwem/chemicals/Chromium6/> (Sept. 2002)
2. California Department of Health Services. *State to Develop Health Goal, Seeks Scientific*

*Review of Chromium 6 in Drinking Water*. Press Release, 27 March 2001  
<http://www.dhs.ca.gov/opa/prssrels/2001/18-01.htm>

3. California Environmental Protection Agency / Regional Water Quality Control Board, Central Valley Region. August 2000. *A Compilation of Water Quality Goals*. Prepared by Jon B. Marshack.  
[http://www.swrcb.ca.gov/rwqcb5/available\\_documents/wq\\_goals/wq\\_goals.pdf](http://www.swrcb.ca.gov/rwqcb5/available_documents/wq_goals/wq_goals.pdf)
4. Haman, Dorota Z. and Del B. Bottcher; University of Florida, Cooperative Extension Service, *Home Water Quality and Safety Institute of Food and Agricultural Science*,  
[http://edis.ifas.ufl.edu/BODY\\_AE009](http://edis.ifas.ufl.edu/BODY_AE009) (Sept. 2002)
5. Montgomery Watson. April 1998. Technical Memorandum-Hexavalent Chromium in Groundwater, Presidio of San Francisco, Prepared for the U.S. Army Corps of Engineers.
6. U.S. Environmental Protection Agency. April 1999. Field Applications of In-Situ Remediation Technologies: Permeable Reactive Barriers, EPA 542-R-99-002.
7. U.S. Environmental Protection Agency. *National Primary Drinking Water Regulations - Consumer Fact Sheet on Chromium*,  
<http://www.epa.gov/safewater/dwh/c-ioc/chromium.html> (Sept. 2002)
8. U.S. Environmental Protection Agency. 1994. Groundwater Issue: Natural attenuation of Hexavalent Chromium in Groundwater & Soils. Prepared By Robert Puls. EPA/540/S-94/505
9. U.S. Environmental Protection Agency. 1992. Groundwater Issue: Behavior of Metals in Soils. Prepared By Joan McLean and Bert E. Bledsoe. EPA/540/S-92/018.
10. Wang, Yi-Tin. Hexavalent Chromium Reduction by *Bacillus* sp. in a Packed-Bed Bioreactor. *Environmental Science & Technology*; 31(5); 1446-1451.
11. Voleski, Bohumil. Removal of Trivalent and Hexavalent Chromium by Seaweed Biosorbent, *environmental Science & Technology*; 1998; 32(18); 2693-2698.

**FOR MORE INFORMATION, CONTACT:**  
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Groundwater Information Sheet: Total Chromium  
Figure 1



**Active and Standby DHS Wells (49 Total) with at Least  
One Detection of Total Chromium  $\geq$  50 PPB MCL**

Source: 1984 - 2000 DHS Data (Map Revised 10/02/02)

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Groundwater Information Sheet: Total Chromium  
Figure 2



**Abandoned, Destroyed, and Inactive DHS Wells (14 Total) with  
at Least One Detection of Total Chromium  $\geq$  50 PPB MCL**

Source: 1984 - 2000 DHS Data (Map Revised 10/02/02)

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